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(12) UK Patent Application (19) GB (11) 2 078 536 A

(21) Application No **8119260**
(22) Date of filing **23 Jun 1981**
(30) Priority data
(31) **161863**
(32) **23 Jun 1980**
(33) **United States of America (US)**
(43) Application published **13 Jan 1982**
(51) **INT CL³ B01D 27/00 // 27/02 27/06**
(52) Domestic classification **B1D 1107 1108 1110 1303 1501 1503 1605 1612 1707 1803 1808 1817 1906 2304 2305 BC**
(56) Documents cited **GB 1500941 GB 1163311 GB 752029 GB 678025**
(58) Field of search **B1D**

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(54) **Fuel filter assembly and cartridge**

(57) A fuel filter assembly and cartridge (1) for filtering, coalescing and separating solids, liquids, and gases from a liquid fuel flow including a housing (4) adapted to receive a removable cartridge (40). The cartridge (40) is in the form of an annular member having an outer annular filtering section (51) to remove solids and an inner annular coalescing section (52) to cause emulsified liquids, e.g. water, to form readily removable droplets in the flow. A separator (60) is situated within the inner periphery of the coalescing section (52) to deflect coalesced liquid for separation whilst permitting passage of the purified fluid therethrough. The coalesced liquid collects in a bowl 20 from which it can be drained off periodically.

FIG_2

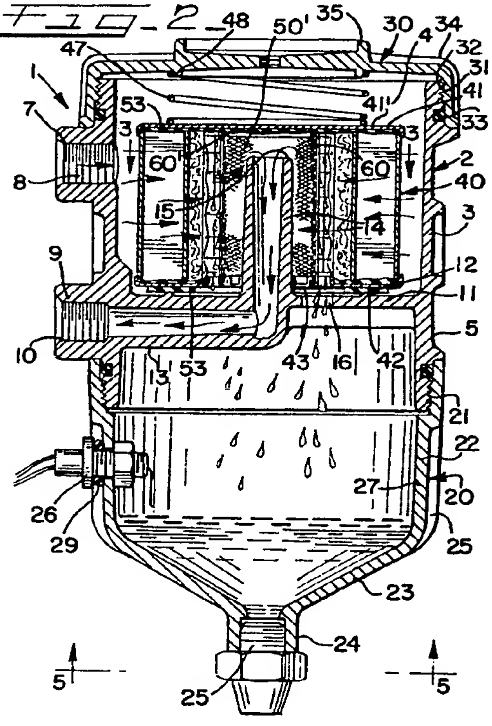

FIG_3

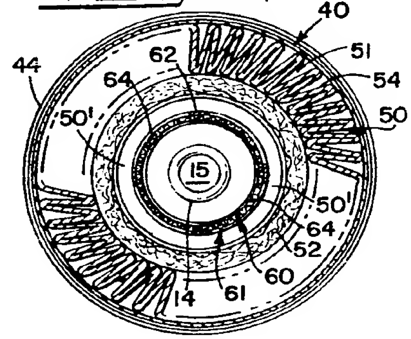

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Fig-1-

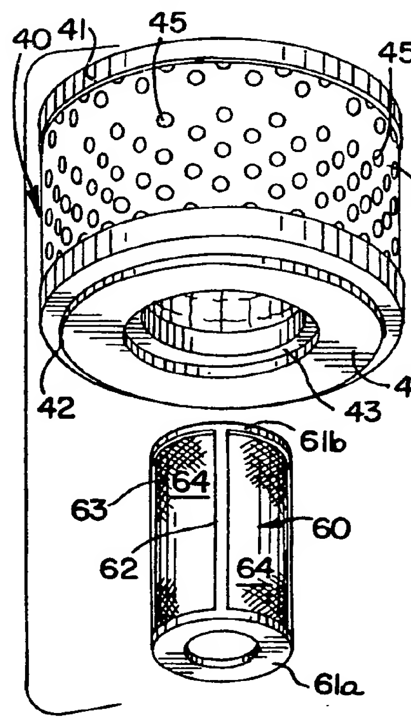


Fig-2-

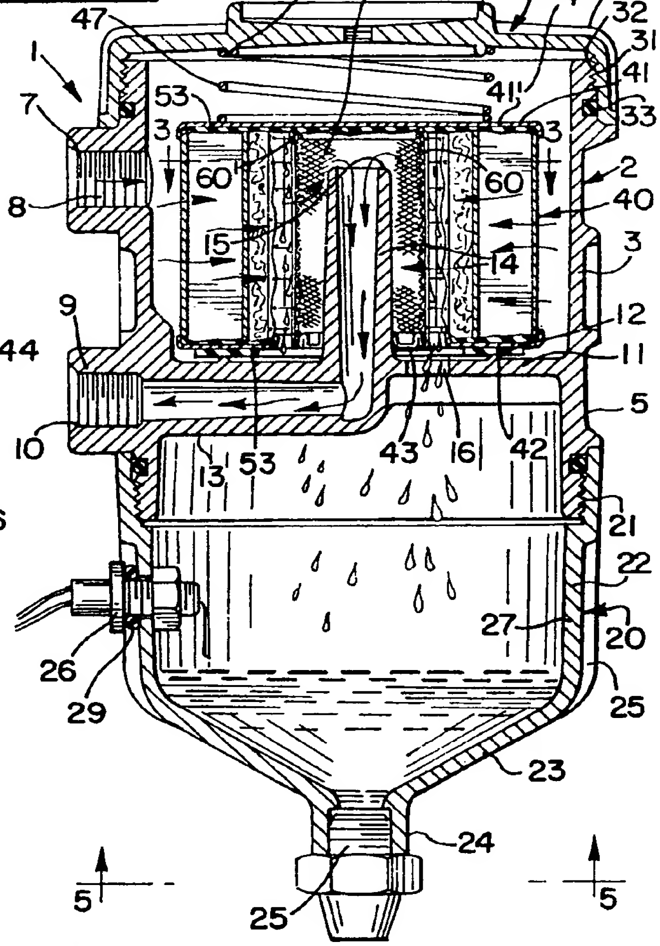
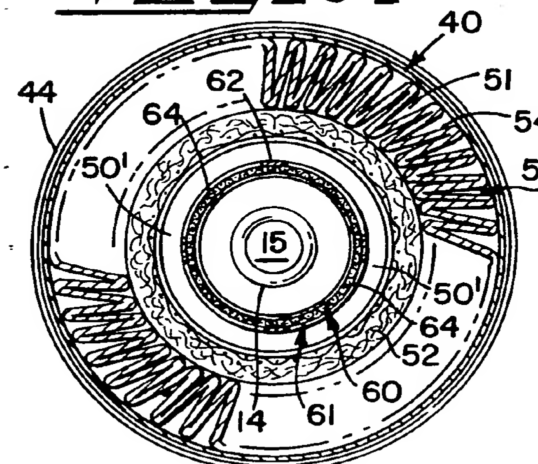


Fig-3-



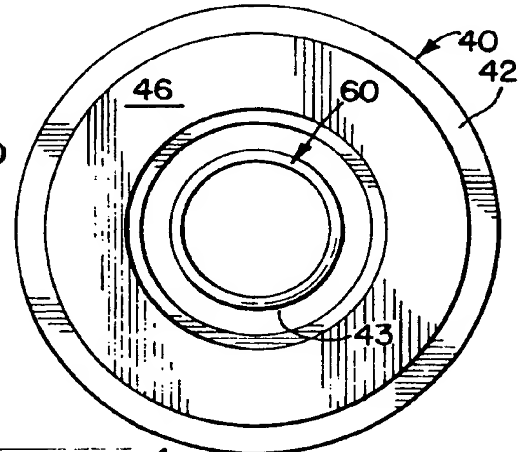


Fig-4-

FIG. 5

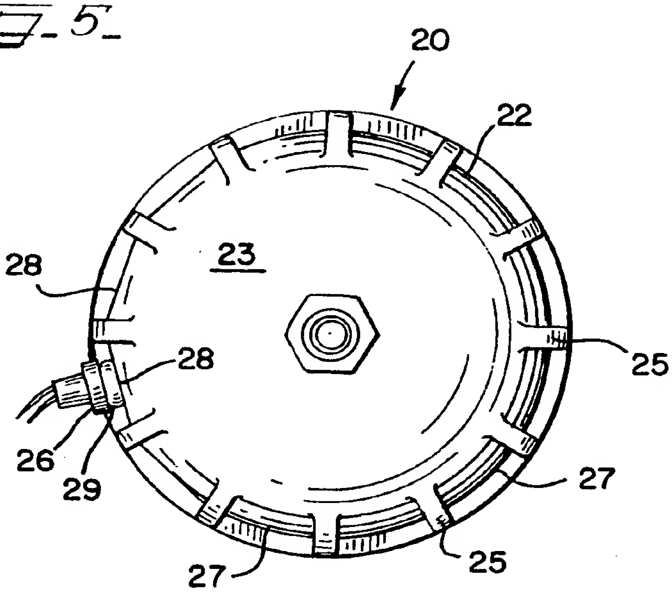


FIG. 6

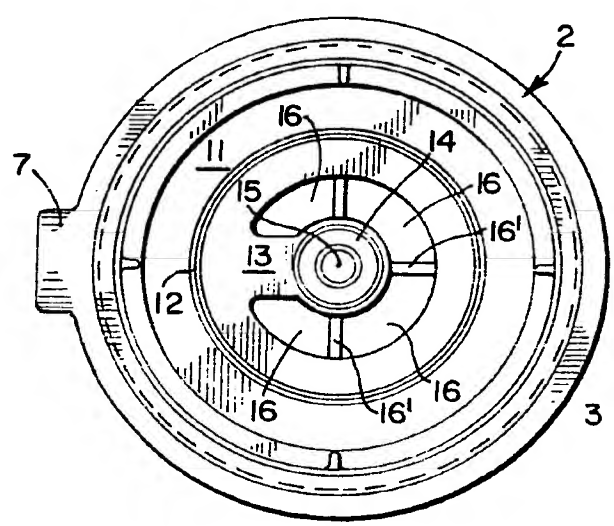


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FIG_7_

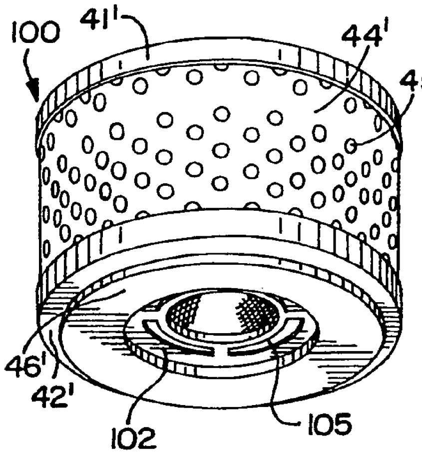
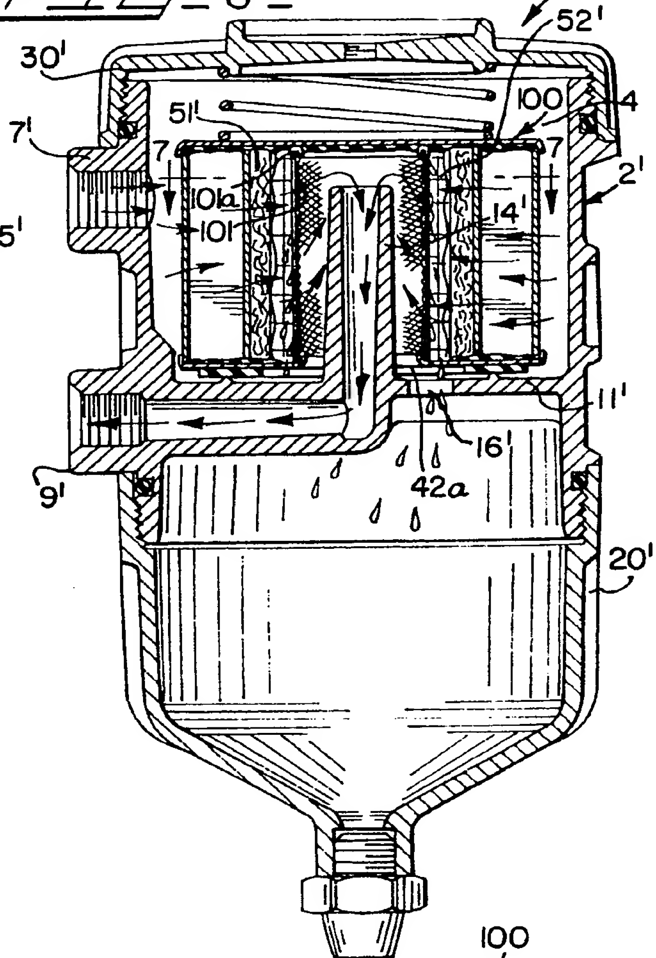


FIG_8_



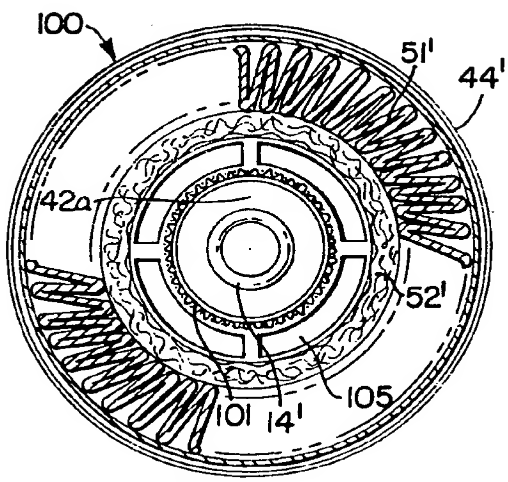


FIG_9_

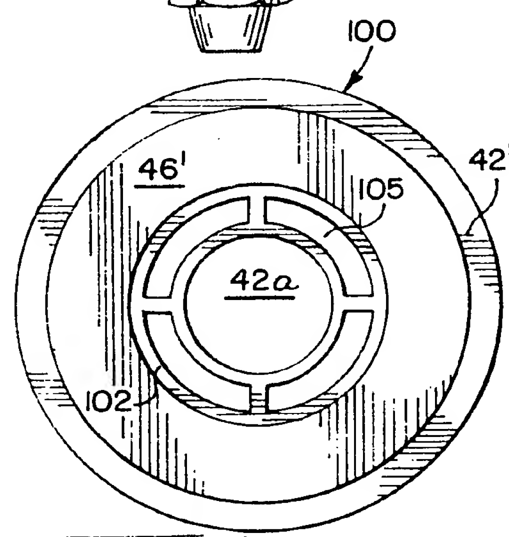


FIG_10_

SPECIFICATION

Improved fuel filter assembly and cartridg

The present invention relates to filtration and liquid/liquid and gas/liquid separation, and more particularly relates to an assembly f r removing solids, liquids and/or gases from a liquid or gas flow.

More specifically, the present invention relates to an improved filter assembly and cartridge to subject a liquid or gas to filtering, coalescing, and separation to remove solids, emulsified liquids and/or gases therefrom. The present invention also relates to a replaceable cartridge capable of filtering and separation to return a purified liquid or gas to a fluid system.

In numerous situations, a continuous liquid or gas phase is subject to the accumulation of contaminants in the form of solid particles, liquids and/or gases, and must subsequently be subjected to filtration and separation as attempted by numerous techniques of the prior art. The contaminating material may, for example, be present as a solid, liquid, or gas within a gas media, or dispersed as a solid, liquid or gas within a liquid. In one specific situation, the presence of foreign matter is prevalent in the fuel system used in conjunction with vehicle engines of many types. The oil in the fuel system of a diesel engine is particularly vulnerable to the presence of contaminants. Such contaminants in diesel fuel may be in the form of solids, such as dirt and rust particles, or constitute water existing as a dispersed phase within the fuel. Fuels, such as diesel oil, demonstrate a natural affinity to water, and because of this water is commonly emulsified within the fluid. The normal turbulent nature of a conventional pump acting to deliver fuel to the engine contributes to the emulsified nature of the water particles within the continuous fuel phase. This widely dispersed liquid is generally difficult to separate from the fluid in such an emulsified state. The presence of contaminating solids and dispersed liquids within the continuous fuel phase is capable of interfering with the efficient operation of the engine and require removal from the fuel.

Many devices have been employed in the prior art in an effort effectively to remove or reduce the amount of contaminating solids, liquids and/or gases, present in liquids or gas, such as, for example, in the form of diesel oils and the like. One type of well known purifying technique used in conjunction with the fuel line of a vehicle applies filtering elements as a means to purify the fuel for satisfactory utilization by the engine. Filtration alone, however, is not effective in removing the contaminating liquids dispersed throughout the fuel, although filtering can, in certain situations, be effective for removing solids. Other prior art devices have been directed to centrifugal type systems by means of which separation of contaminants from the fuel is obtained by subjecting the fluid to a swirling action. Although such techniques are capable of a degree of satisfactory separation of foreign material from a fluid, these devices do not offer an efficient and relatively inexpensive approach to the problem of removal of contaminants.

Many devices in the prior art have relied upon the phenomenon of coalescing dispersed liquid from a fluid as a means to overcome the problems inherent in the accumulation of liquid in a fuel line. Such coalescing devices rely on a coalescing material to coal sc the liquids into droplets which are more readily separated from the fuel than when in the dispersed state. The prior art coalescing devices have been deficient in providing an economical and trouble free device that is capable of highly efficient removal of dispersed liquids in all demand ranges of the vehicle engine. Some of the prior art devices may operate satisfactorily at low flow rates through the separator, but as the engine output increases, the flow rate becomes greater and efficiency of coalescing and separation then suffers in such devices resulting in water particles, and the like, being delivered to the engine. The overall deficiency of such coalescing systems has resulted, in part, from the ineffective cooperation between the incoming flow and the coalescing state.

Moreover, known coalescing-type apparatus have failed to provide or have not provided sufficient filtration of solids prior to entry to the coalescing stage, because of which the coalescing operation becomes less efficient due to the interfering presence of solids. In addition, the prior art coalescing devices have not provided effective filtration and separation at all flow rates through the separator, with a resulting decrease of efficiency. Accordingly, the known techniques of filtering and separating contaminants from a fluid, such as a diesel oil and the like, have not attained the optimum level of efficiency to accomplish removal of solids, dispersed liquids and gases from a fuel at all demand levels of the engine.

According to one aspect of the present invention there is provided an apparatus for removing contaminants from a fluid comprising

housing means forming a fluid receiving chamber, the housing means including an inlet port for introducing a continuous fluid phase having particulate material and emulsified liquids to be removed to said fluid receiving chamber, and an output port to direct the fluid to a utilization point;

cartridge means operatively positioned in the fluid receiving chamber and adapted to be selectively removed for the replacement, the cartridge means having at least two concentrically arranged annular sections to receive the fluid introduced through said inlet port in successive order and in a substantially radial inward direction,

the outer section of the annular sections including filtering means to filter the particulate material from the fluid introduced through the inlet port, said filtering means having a filter media disposed therein,

the inner section of said annular section including coalescing means to coalesce the emulsified liquids in the continuous fluid phase, the coalescing means having a coalescing material to cause said emulsified liquid to coalesce into droplets in the continuous fluid phase,

an annular separator concentrically arranged within the coalescing means in spaced relationship thereto for

preventing the passage of the droplets formed by said coalescing section and permitting the continuous fluid phase to pass therethrough,

containment means coupled in fluid communication beneath the housing means to collect the coalesced liquid, and

fluid passage means positioned within the annular separator and being in fluid communication with said outlet port to direct the continuous fluid phase passing through said separator to a utilization point.

In another aspect, the present invention provides a fuel filter and separator assembly comprising housing means forming a fuel filter and separator chamber, the housing means having an inlet coupled to a vehicle fuel sustem to introduce a flow of fuel into said chamber, the fuel having solid and liquid contaminants therein, and the housing means further having an outlet to deliver the fuel to an engine,

cartridge means removably mounted in the chamber, the cartridge means having an outer annular filter section and an inner concentrically arranged coalescing section, the flow of fuel introduced into the inlet being directable substantially radially inward through the filter section to remove the solid contaminants and through the coalescing section to coalesce the liquid contaminants into droplets,

an annular liquid separator concentrically disposed within the cartridge means in spaced relation thereto and defining an inner fuel receiving chamber, the annular separator preventing the passage of coalesced liquids therethrough but permitting passage of the fuel,

containment means coupled to the housing means beneath the cartridge means and the separator to receive and collect said droplets, and

fluid passage means in fluid communication with the fuel receiving chamber and coupled to said outlet to direct substantially contaminant free fuel to the engine.

In a further aspect of present invention provides a removable cartridge for use in a fuel filter assembly comprising

an annular outer filter section and an inner coalescing section concentrically arranged within the outer filter section in juxtapositioned relationship thereto, the filter and coalescing section defining a central chamber,

a perforated shell disposed in surrounding relationship to said annular outer section to form an outer surface to receive an incoming flow of fluid,

an upper cap member affixed to a first end portion of the perforated shell, the filter section, and the coalescing section to enclose an end of said chamber,

a bottom cap member affixed to a second end portion of the perforated shell, the filter section and the coalescing section and having a central opening in fluid communication with the chamber, and in which

the bottom cap member has annular sealing means adapted to create sealing relationship between the cartridge and the fuel filter assembly.

The present invention enables the provision of an improved fluid filter assembly and cartridge for removing solids, liquids, and/or gas from a fluid media, such as a liquid or gas. The present invention may be utilized in a variety of applications where separation and removal of solids, liquids and/or gases from a continuous liquid or gas phase is necessary. Although the present invention may be employed to filter solids and separate a liquid form a fuel, the fluid filter assembly and cartridge disclosed herein may also be used to accomplish two, three or four phase liquid separation, gas/liquid separation or gas filtration, as conditions dictate. For example, the present invention may be employed to remove solids and/or moisture or other liquid from a gas, such as air being supplied to a pneumatic compressor, to remove contaminating liquids or gases in natural gas, propane and the like, to remove oil or other contaminating liquid from bilge water, and numerous other particular applications.

In a specific use of the invention, the fuel filter assembly and cartridge is adapted to be attached to the fuel line of a vehicle. In such use, contaminated fuel is directed in a substantially radially inward direction through an annular cartridge means having filtering and coalescing stages. The filtering state effectively removes and retains solids from the flow and introduces fuel, free of solids, radially through the coalescing stage. In the coalescing stage, emulsified liquids, such as water and the like, agglomerate to form droplets which increase in size during inward movement. The dispersed liquid is thus transformed in the coalescing stage of the assembly of the present invention into a physical state of sufficient size and weight to be separated from the fuel and collected in a containment vessel as needed during operation of the vehicle. A separator is positioned in operative relationship to the coalescing stage to ensure complete separation of the coalesced liquid from the fuel, even at higher flow rates through the filter assembly.

The separator of the fuel filter assembly and cartridge herein disclosed is impermeable to any coalesced liquid carried by the fuel and acts to deflect agglomerated water away from its surface to be collected by the contaminant vessel. At the same time, the separator is fuel permeable to permit the fuel to flow unimpeded to the outlet of the assembly. Through its filtering, coalescing, and separating functions, the present invention achieves greatly improved removal of foreing substances from the fuel system of an engine, or in other uses where such efficient filtration and separation is desirable.

Reference is now made to the accompanying drawings wherein like reference numerals indicate corresponding parts throughout, and in which:–

Figure 1 is a perspective exploded side view of a first embodiment of a cartridge having a separable separator member for use in the fuel filter assembly and cartridge of the present invention;

Figure 2 is a side sectional view of the fuel filter assembly of the invention employing the cartridge shown in Figure 1;

Figure 3 is a sectional top view of the cartridge assembly shown in Figure 1 within the fuel filter assembly taken along the line 3-3 of Figure 2 looking in the direction of the arrows;

Figure 4 is a bottom schematic view of the car-

tridge assembly shown in Figure 1 with the separator member in an inserted position therein;

Figure 5 is a schematic illustration of the containment vessel of the fuel filter assembly and cartridge of the invention taken along the line 5-5 of Figure 2 looking in the direction of the arrows;

Figure 6 is a top schematic illustration of th fuel filter assembly shown in Figure 2 with the cartridge and body cap member removed;

Figure 7 is a perspective side illustration of a second embodiment of a cartridge for use in the fuel filter assembly and cartridge of the present invention;

Figure 8 is a side sectional view of the fuel filter assembly and cartridge of the present invention employing the cartridge shown in Figure 7;

Figure 9 is a sectional view of the fuel filter assembly and cartridge shown in Figure 8 taken along the line 7-7 of Figure 8 looking in the direction of the arrows; and

Figure 10 is a bottom schematic view of the cartridge shown in Figure 7 used in the fuel assembly and cartridge shown in Figure 8.

Referring to Figures 1 to 6, there is illustrated a first embodiment of the fluid filter assembly and cartridge of the present invention, generally designated by reference numeral 1. The fluid filter assembly 1 is capable of highly effective filtering, coalescing and separation to remove particles, liquids and gases from a fluid such as, for example, the fuel in the fuel system of an engine for an automobile, truck, off-highway vehicle, aircraft and marine craft, or other applications, apart from fuel systems, involving marine, industrial or other uses.

Although the fluid filter assembly and cartridge 1 is described for the purposes of illustration for use to remove impurities from the fuel supplied to a vehicle engine, it should be understood that the present invention is not limited to such use and may be utilized in numerous other applications where removal of contaminants, in the form of dispersed particles, liquids and/or gases, from a liquid or gas is desirable. The present invention may be used to purify natural gas, propane, bilge water, air in pneumatic systems, and the like, in which unwanted solids, liquids, or gases may be carried. The present invention may also be used for other than single phase separation, and can be used in a situation where two, three or four phase liquid separation, gas liquid separation or gas filtration is required.

In the specific use disclosed herein, the fluid filter assembly 1 in the form of a fuel filter and cartridge, includes a body 2 having an upper wall 3 in cylindrical form to define a cartridge receiving chamber 4 therein. An integral lower cylindrical wall 5 is coupled to the upper wall 3 and is adapted to be attached to a containment vessel or bowl in a manner to be described hereinafter. The walls 3 and 5 may be constructed from any suitable material, such as, for example, a metal or plastics. An inlet port 7 is formed through a portion of the upper wall 3 and is provided with internal threads 8 to permit the inlet port to be coupled to a conduit of the fuel system (not shown) of a vehicle to introduce a flow of fuel, having contaminants to be removed, into the cartridge receiving chamber 4. Although the fuel filter assembly 1 may be employed in conjunction with the fuel system of any internal combustion engine, the present invention is particularly useful in removing foreing material from the diesel oil of a diesel engine. Diesel fuel is particularly subject to contamination due t the presence of solid material in the form of dirt, rust, and the like, and emulsified liquids, such as water, generally having a different specific gravity to that of the diesel fuel. The contaminated fuel is normally delivered to the inlet port 7 by means of a conventional fuel pump (not shown) forming a component of the engine fuel system. The flow rate through the unit is established by the fuel pump in conjunction with the instantaneous fuel requirements of the engine.

An outlet port 9 is provided beneath the inlet port 7 through a portion of the lower wall section 5 and is similarly provided with internal threads 10 permitting attachment to another conduit of the fuel system to direct purified fuel to a utilization point, generally to be supplied to the engine during its operation. The bottom of the cartridge receiving chamber 4 is defined by a horizontal wall 11, formed with an upper annular shaped ridge 12, circumferentially extending about the vertical axis of the body 2. An outlet passage 13 is integrally coupled to the underside of the lower wall 12 and is in fluid communication with the outlet port 9. The outlet passage 13 creates a fluid passage laterally of the body 2 to a point adjacent its vertically centre axis. An integrally formed standpipe 14 extends upwardly through the lower wall 11 to a position in an upper portion of the cartridge receiving chamber 4. The standpipe 14 creates a fluid passage in communication with outlet passage 13 and is provided with a standpipe inlet port 15 through which the flow of fuel, having been purified in a manner to be described hereinafter, is directed downward through the standpipe 14 and then laterally through the passage 13 for egress from the port 9 for utilization in the vehicle engine.

A plurality of containment vessel ports 16 in the form of arcuate, open segments are disposed about the standpipe 14 and through bottom wall 11 as is best shown in Figures 2 and 6. Each of the ports 16 is separated by respective narrow portions 16' of the bottom wall 11 and extend about the vertical centre line of the body 3 from points adjacent opposite sides of the flow passage 13. The ports 16 provide drainage openings for the liquid separated from the fuel in the cartridge receiving chamber 4 during the use of fuel filter assembly 1 of the present invention. A containment vessel or bowl 20 is removably attached by a threaded coupling 21 to the bottom end portion of the wall 5, and the coupling 21 may be sealed through the use of a suitable elastomeric O-ring 22. The containment vessel 20 may be constructed from numerous materials such as, for example, plastics, steel or bronze.

As is best shown in Figures 2 and 5, the containment vessel 20 includes an upper cylindrical portion 22 and a lower frusto-conical bottom wall 23, which terminates with an outlet neck 24 fitted with a suitable drain plug or valve 25. The plug 25 permits drainage of the liquid collected in the interior

chamber formed by the containment vessel 20. Although the drain plug 25 is illustrated as a conventional, manually operated drain valve capable of alternatively blocking or draining liquid through outlet neck 24, it is possible to fit the outlet neck 24 with an automatically operated valving mechanism controlled by a suitable liquid level detector disposed within the containment vessel 20 of the type as will be described hereinafter.

The containment vessel 20 may be drained manually or automatically through the neck 24 on a periodic basis upon a predetermined quantity of liquid having been collected. As shown in Figure 2, a conventional conductivity probe 26 may be disposed through the upper portion 22 of the containment vessel 20 to provide the vehicle operator with a visual or audio signal, through suitable circuitry (not shown), that a predetermined level of liquid has accumulated within the containment vessel and thus requires drainage. Alternatively, the probe 26 may be coupled to an electrical circuit (not shown) which applies an electrical signal to an automatically operated drain valve (not shown) positioned in the outlet neck 24 to open and close the valve as conditions dictate. The amount of fluid collected in the containment vessel 20 may also be determined visually, when the containment vessel 20 is constructed of a transparent material. It is also possible to use other types of well known liquid level detectors within the vessel 20, other than the conductivity probe 26 shown in Figure 2.

As is shown in Figure 5, the upper cylindrical portion 22 of the containment vessel 20 is formed by a plurality of downwardly disposed rib sections 25 interconnected by a plurality of wall segments 27. Although a majority of the segments 27 possess a curved cross-sectional configuration, one or more segments 28 possess a flat shape. The flat surface created by the segment 28 in which the conductivity probe 26 is disposed achieves an improved sealing relationship between the conductivity probe 26 and the wall of the containment vessel 20, by ensuring positive contact between the wall of the segment 28 and the O-ring 29 employed as a seal for the mounting of the probe 26.

The top of housing assembly 2 is covered by a dome-shaped cap member 30. A plurality of lower threads 31 are formed within the downwardly extending portion of cap member 30 and are adapted to engage threads 32 formed on the periphery of the upper portion 3 of the body 2. The cap 30 may be removed to provide access to the cartridge chamber 4 and thus permit removal and replacement of the cartridge mounted therein as is needed during use of the device. The sealing relationship between the cap 30 and the body 2 is enhanced by a suitable O-ring 33 positioned adjacent the threaded coupling therebetween. The dome-shaped cap 30 is provided with a number of outer rib sections 34 extending from an upper rim 35 of the cap 30 downwardly to near its bottom edge. The ribs 34 act to facilitate manual removal of the cap member 30 when it is necessary to replace a cartridge in the cartridge chamber 4.

A unitary cartridge assembly 40, which is capable of filtering and/or coalescing contaminating solids, liquids, and gases from the fuel, is designed to be removably received in cartridge chamber 4 within the body 2. The cartridge assembly 40 is in the form of an annular member having filtering and coalescing sections as will be described hereinbelow. The cartridge assembly 40 is adapted to be inserted in and removed from the body 2 through the opening which is normally closed by the cap member 30, as is shown in Figure 2. The cartridge assembly 40 includes an upper cartridge cap 41 forming a continuous surface 41' and a bottom annular cap 42 defining a central opening 43 through which the standpipe 14 extends upwardly. The outer circumferential wall of the cartridge assembly 40 is defined by a cylindrical surface 44 in the form of a shell of paper or similar material. The shell 44 includes a plurality of perforations 45 situated at selected positions around the entire circumference of the shell 44 to form multiple, circumferentially disposed inlets to the cartridge assembly 40 for the flow of fuel introduced through inlet 7.

The bottom cap 42 of the cartridge assembly 40 includes an elastomeric annular gasket 46, which is biased into sealing contact against the annular rim 12 formed on the bottom wall 11 of the body 2. The cartridge assembly 40 is biased downwardly into position in the cartridge chamber 4 and into contact with the rim 12 by means of a compression spring 47. The spring 47 is disposed between the upper cartridge cap 41 and the bottom of the cap member 30, which has an annular spring retention lip 48 as is shown in Figure 2. The spring 47 may be any type of compression spring capable of holding the cartridge assembly 44 down in the biased position as illustrated in Figure 2.

The cartridge assembly 40 includes an annular body 50 disposed within the shell 44, such that fluid introduced through the perforations 45 is directed radially inward through the annular body 50 to filter and coalesce impurities. The annular body 50 of the cartridge assembly 40 surrounds a central chamber 50' in which the standpipe 14 is disposed with the standpipe inlet 15 being positioned at an upper portion thereof. The central chamber 50' is in fluid communication with the containment vessel 20 by means of the ports 16 which drain coalesced liquid separated from the flow of fluid. The annular body 50 is formed by an outer filtering section 51 and an inner coalescing section 52 which are arranged in concentric, substantially contacting relationship with each other. The ends of the shell 44, filtering section 51, and the coalescing section 52 are affixed to the upper cartridge cap 41 and the lower cartridge cap 42 by the use of a suitable adhesive 53, such as an epoxy adhesive, to form a unitary cartridge structure.

The filtering section 51, which is situated immediately adjacent the perforated paper jacket 45, is formed by a pleated filter media 54 extending circumferentially about the vertical axis of the body 2 and is capable of removing and retaining solid particles present in the flow of diesel oil. The pleated filtering media 54 comprises a conventional filtering material, such as, for example, a porous paper tre-

ated with a silicone substance, to render the filter paper hydrophobic in nature. Th filter media is capable of filtering and retaining solids from the fuel flow and may be constructed so as to provide filtration in a predetermined range, such as coarse filtration, fine filtration, or absolute filtration from a size of a large number of microns or below.

After passing through the filtering section 51 where solids are filtered from the flow, the fuel is passed substantially in a radially inward direction through the coalescing section 52. The coalescing section 52, which is also of annular configuration, is situated in abutting or near abutting relationship to the inner surface of the outer filtering section 51. The coalescing section 52 is formed from any coalescing material that casuses emulsified water or other liquids, generally having a different specific gravity to that of the fuel, to coalesce and form droplets which increase in size during inward travel through the coalescing media. Typically, such coalescing material causes emulsified liquid particles, dispersed in the continuous fluid phase, to agglomerate and form droplets which increase in size during inward travel through the coalescing section 52. The droplets of water and the like formed in the coalescing section 52, either fall by gravity to the bottom of the chamber 50′ or are carried radially inward from the coalescing section 52 by the flow of fuel. The droplets carried inward by the fuel flow are separated therefrom by means of a separator member 60, which prevents passage of the coalesced liquid, but permits passage of the contaminant free fuel oil. Generally, many relatively heavier droplets of water fall to the bottom of the chamber without contact with the separator member 60, particularly under low rate conditions, while the relatively lighter droplets may be carried by the flow to the separator member. However, higher flow rates through the fuel assembly 1, induced by the fuel pump acting to meet increased demands of the engine, tend to carry even some of the relatively heavier droplets into contact with the separator member 40.

As is best shown in Figures 1, 2 and 3, the separator member 60 comprises an annular structure separably coupled to the cartridge assembly 40 in engagement means 60′ carried thereby. The separator member 60 is disposed in concentric relationship to standpipe 14 within the chamber 50′ and is supported by the inner periphery of a lower ring member 61*a* of member 60 frictionally engaging a portion of the standpipe 14 to suspend the separator member in the position shown in Figure 2. The outer periphery of the separator member 60 is spaced from the inner surface of the coalescing section 52 and is spaced from the outer periphery of the standpipe 14 as shown in Figure 2. The separator member 60 includes an annular frame having the ring member 61*a* and an upper ring member 61*b* interconnected by a plurality of spaced longitudinal reinforcing segments 62 forming peripheral openings 63. The positioning of the top ring 61*b* in the engagement means 60′ of the cartridge cap 41 and the lower ring 61*a* in frictional engagement on standpipe 14 substantially prevents fluid communication through the upper and lower ends of the separator member 60. The openings 63 are covered by fine mesh screen elements 64 formed by a separating hydrophobic media, such as metal, plastics, treated paper or a similar material capable of preventing the droplets of coalesced liquids from passing therethrough, but being permeable to the passage of the fuel therethrough. The screen 64 separates the droplets of liquid contacting the separator member 60 from the fuel by deflection and causes the agglomerated liquid to fall by gravity downward in chamber 50′ between the cartridge assembly 40 and the separator member 60 as is shown in Figure 2. The droplets thus drain from the chamber 4 through the ports 16 and into the containment vessel 20 after passing through the screen element 64. The purified fuel flows upwards through the standpipe inlet 15 to the outlet port 9 for delivery to the vehicle engine.

In operation, a flow of fuel is introduced through the inlet port 7 by the action of the engine fuel pump. The fuel may carry emulsified liquids, such as water and the like, and particulate materials in the form of rust, dirt and similar solids. The fluid entering the inlet 7 substantially fills the chamber surrounding the cartridge assembly 40 and is directed radially through the outer perforated shell 44 of the cartridge. The fuel passes in a substantially inward direction through the filtering section 51, at which stage the solids are removed from the fluid and retained by the filtering media. The remaining fuel, containing emulsified contaminants, such as water, then passes through the coalescing section 52. The coalescing section 52 acts to coalesce the liquids dispersed in the continuous fuel phase and to agglomerate and form droplets which become larger in size during their travel through the coalescing section.

The heavier droplets fall by gravity to the bottom of cartridge chamber 4 while the remaining droplets contact the screen 64 of the separator member 60. The number of droplets actually contacting the separator member 60 is largely dependent upon the flow rate through the filter assembly and other conditions. The coalesced liquid is deflected by the hydrophobic screen elements 64 and falls downwards to be drained into the containment vessel 20 through the ports 16. The purified fuel, which is permitted to pass through the separator member 60, enters the space about the standpipe and flows through the standpipe inlet 15 and downward to the outlet port 9 for delivery to the vehicle engine. Thus, the solids in the fuel are removed by the filtering section 51 while the liquid contaminants form droplets in the coalescing section 52 that are separated from the fuel flow by gravity and by the aid of the separator member 60, if in contact therewith.

Referring now to Figures 7 to 10, there is illustrated another embodiment of the fuel filter assembly and cartridge of the present invention which utilizes a modified cartridge 100. The fuel filter assembly 1′ of the embodiment shown in Figures 7 to 10 is provided with substantially the same structural components accomplishing the same functions as those described in connection with the preceding embodiment described with reference to Figures 1 to

6. The fuel filt r assembly 1 includes a body 2', a containment vessel 20', an upper cap 30', a bottom wall 11' having ports 16', a standpipe 14' and other identical parts to the preceding embodiment The fluid flow through the filter assembly 100 is identical to that disclosed with reference to Figures 1 to 6, with the fuel flowing into the port 7' and egressing from the outlet port 9'.

The modified cartridge assembly 100 shown in Figures 7 to 10 is formed with an integral separator member 101 to separate coalesced liquid from the fuel by performing the same function as the separator member 60 shown in Figures 1 to 6. The cartridge assembly 100 shown in Figures 7 to 10 includes an upper cap 41' and a lower cap 42' having a gasket 46', similar to that described with reference to the cartridge assembly 40 of the preceding embodiment. The outer periphery of the cartridge assembly 100 of the embodiment shown in Figures 7 to 10 is defined by an annular continuous perforated sheet 44' surrounding an annular filtering section 51' having a pleated filter media. The coalescing section 52' of the cartridge assembly 100 is also situated adjacent the filtering section 51' and includes a suitable coalescing material.

The lower annular 42' forms a standpipe receiving opening 42a and supports the separator member 101 by means of an inner upturned end portion 102 as shown in Figure 7, such that the separator 101 is carried as an internal part of the cartridge assembly 100. The upper portion of the outer shell 44', the filtering section 51', and the coalescing section 52' are affixed by an adhesive to the underside of the upper cap 41', along with a retention element 101a which receives the upper end of the separator member 101. The separator member 101 is integrally situated in the unitary cartridge assembly 100 at a position spaced from the inner surface of the coalescing section 52' to permit effective separation of the coalesced liquid. The droplets of coalesced liquid created in the coalescing section 52' drop downwards in chamber 4 in a similar manner to that described in the preceding embodiment. A plurality of drainage segments 105 are provided in the lower cap 42', and are arranged beneath the falling droplets to permit the coalesced liquid to drain downward to the ports 16' for collection in the containment vessel 20'. The purified fuel then flows to the standpipe inlet 15' and downwards through the standpipe 14' for delivery to the engine in the manner as described above.

In the foregoing description, the present invention has been described in detail as a single unit to remove impurities from a fuel. The fluid filters 1 and 1' may also be employed as a fuel or other filter together with additional units (not shown) mounted in parallel or other relationship to each other to function simultaneously or alternatively, in a sequential mode as each fluid filter becomes incapable of further filtration or separation after extended use. In the latter sequential operation of a plurality of units of the present invention, suitable manual or automatic flow control means may be relied upon to deliver or cease delivery to a particular assembly.

The fluid filter assembly may also comprise a large unit having a plurality of separate internal filtering, coalescing, and separating components of the type, for example, described with reference to the accompanying drawings. In addition, in certain applications, the filter assembly 1 or 1' can be operated in a manner such that contaminants separated are removed through the outlet while the utilized flow is directed through the bottom of the filter assembly. Such modification may be utilized in particular situations, such as, for example, for removing contaminating oil from bilge water being discharged into a natural body of water.

CLAIMS

1. An apparatus for removing contaminants from a fluid comprising

housing means forming a fluid receiving chamber, the

housing means including an inlet port for introducing a continuous fluid phase having particulate material and emulsified liquids to be removed to said fluid receiving chamber, and an output port to direct the fluid to a utilization point;

cartridge means operatively positioned in the fluid receiving chamber and adapted to be selectively removed for replacement, the cartridge means having at least two concentrically arranged annular sections to receive the fluid introduced through said inlet port in successive order and in a substantially radially inward direction,

the outer section of the annular sections including filtering means to filter the particulate material from the fluid introduced through the inlet port, said filtering means having a filter media disposed therein,

the inner section of said annular section including coalescing means to coalesce the emulsified liquids in the continuous fluid phase, the coalescing means having a coalescing material to cause said emulsified liquid to coalesce into droplets in the continuous fluid phase,

an annular separator concentrically arranged within the coalescing means in spaced relationship thereto for

preventing the passage of the droplets formed by said coalescing section and permitting the continuous fluid phase to pass therethrough,

containment means coupled in fluid communication beneath the housing means to collect the coalesced liquid, and

fluid passage means positioned within the annular separator and being in fluid communication with said outlet port to direct the continuous fluid phase passing through said separator to a utilization point.

2. An apparatus as claimed in Claim 1 wherein the emulsified liquids are carried in a fluid having a different specific gravity therefrom.

3. An apparatus as claimed in Claim 1 or Claim 2 wherein the fluid passage means includes a standpipe disposed within the annular separator.

4. An apparatus as claimed in any of Claims 1 to 3 wherein the annular separator is in the form of an annular fine mesh screen.

5. An apparatus as claimed in any of Claims 1 to 4 wherein the filter media is in the form of pleated paper treated with a hydrophobic substance.

6. An apparatus as claimed in any of Claims 1 to

5 wherein the coalescing material includes a fibreglass material.

7. An apparatus as claimed in any of Claims 1 to 6 wherein said separator is integrally coupled to said cartridge means.

8. A fuel filter and separator assembly comprising housing means forming a fuel filter and separator chamber, the

housing means having an inlet coupled to a vehicle fuel system to introduce a flow of fuel into said chamber, the fuel having solid and liquid contaminants therein and the housing means further having an outlet to deliver the fuel to an engine,

cartridge means removably mounted in the chamber, the cartridge means having an outer annular filter section and an inner concentrically arranged coalescing section, the

flow of fuel introduced into the inlet being directable substantially radially inward through the filter section to remove the solid contaminants and through the coalescing section to coalesce the liquid contaminants into droplets,

an annular liquid separator concentrically disposed within the cartridge means in spaced relation thereto and defining an inner fuel receiving chamber, the annular separator preventing the passage of coalesced liquids therethrough but permitting passage of the fuel,

containment means coupled to the housing means beneath the cartridge means and the separator to receive and collect said droplets, and

fluid passage means in fluid communication with the fuel receiving chamber and coupled to said outlet to direct substantially contaminant free fuel to the engine.

9. A fuel filter and separator assembly as claimed in Claim 8 wherein the annular separator is an annular member having substantial portions in the form of a screen element being impermebale to coalesced liquids but permeable to the fuel.

10. A fuel filter and separator assembly as claimed in Claim 8 or Claim 9 wherein the fluid passage means includes a standpipe disposed concentrically within the separator.

11. A fuel filter and separator assembly as claimed in any of Claims 8 to 10 wherein the separator is integrally attached to the cartridge means.

12. A fuel filter and separator assembly as claimed in any of Claims 8 to 11 wherein the housing means includes a removable top to provide access to the cartridge means in the fuel filter and separator chamber.

13. A fuel filter and separator assembly as claimed in any of Claims 8 to 12 wherein the containment means includes a vessel having a plurality of wall portions separated by a plurality of rib sections.

14. A fuel filter and separator assembly as claimed in Claim 13 wherein at least one of the wall portions has a curved cross-sectional configuration.

15. A fuel filter and separated assembly as claimed in Claim 13 or Claim 14 wherein at least one of the wall portions includes a flat configuration and is adpated for the mounting of a level detector through said vessel in sealed relationship thereto.

16. A removable cartridge for use in a fuel filter assembly comprising

an annular out r filter section and an inner coalescing section concentrically arranged within the outer filter section in juxtapositioned relationship thereto, the filter and coalescing section defining a central chamber,

a perforated shell disposed in surrounding relationship to said annular outer section to form an outer surface to receive an incoming flow of fluid,

an upper cap member affixed to a first end portion of the perforated shell, the filter section, and the coalescing section to enclose an end of said chamber,

a bottom cap member affixed to a second end portion of the perforated shell, the filter section, and the coalescing section and having a central opening in fluid communication with the chamber, and in which

the bottom cap member has annular sealing means adapted to create sealing relationship between the cartridge and the fuel filter assembly.

17. A removable cartridge as claimed in Claim 16 wherein the filter section is formed by a pleated filter material treated with a water repellent substance.

18. A removable cartridge as claimed in Claim 16 or Claim 17 wherein the coalescing section includes a coalescing material to cause liquid contaminants in a fuel introduced radially inward through the coalescing section to coalesce therefrom for separation.

19. A removable cartridge as claimed in any of Claims 16 to 18 which further comprises annular separator means concentrically arranged within the filter section and the coalescing section, the separator means being supported by said bottom cap member.

20. A removable cartridge as claimed in Claim 19 wherein the separator means includes a fine mesh screen for deflecting passage of the coalesced liquid and permitting passage of the fuel.

21. An apparatus for removing contaminants from a fluid substantially as herein described with reference to and as shown in Figures 2, 3, 5, 6 and 8 to 10 of the accompanying drawings.

22. A fuel filter and separator assembly substantially as herein described with reference to and as shown in Figures 2, 3, 5, 6 and 8 to 10 of the accompanying drawings.

23. A removable cartridge for use in a fuel filter assembly substantially as herein described with reference to and as shown in Figures 1, 4 and 7 of the accompanying drawings.

Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1981.
Published at the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.